A Trilogy of Gus Bohne Turbo two-stroke race engines

Gus Bohne of Salem, NH (gus.bohne@comcast.net) cut his teeth on turbocharging two-stroke engines back in the early eighties. He was a disciple of the infamous Mike Mazur who was the first to market Aerocharger systems for two-stroke snowmobiles. All of those early boosted two-strokes were fueled by pressurized carburetors—a black art to this day! When I was involved for many years with Aerocharger we developed turbo kits for too many sleds, all fueled by blowing through 34-38mm carbs. We tried desperately to make larger body 40mm Mikuni carbs work with boost, since those were standard on the bigger SkiDoo and Cat twins, but were unable to do so. So all the kits we developed for those then-big twins back in the nineties had to have small body 38mm Mikuni carbs included with them. When Gus told me a few years ago that he was blowing boost through 44mm round slide carbs on the wickedly fast sleds he was turbocharging I was amazed and impressed. Even with all of my dyno instrumentation and with excellent turbo carb tuners Greg Bennett and Sean Ray trying their best, those big Mikuni carbs were too difficult to create optimal fueling and we gave up on them.

Don Emery of DNE Performance in Hawkstone, Ontario Canada (dneperformance@hotmail.com) had created the monstrous SkiDoo four cylinder engine that powered Tommy McConkey's radar run sled to over 190 MPH with 525ish HP with N2O (those test results are shown on this website). But now Tommy was looking for 200 MPH and to me, turbo boost would be the optimal means to create the HP needed to add 10 mph to top end speed. Aero drag is brutal—increasing as the cube of MPH so lots more power would be needed to accomplish Tommy's goal. We talked about options—EFI and boost go hand in hand, but two strokes are way more finicky than four strokes which deliver a very linear airflow rise as boost increases. But as we know from history, two strokes are way more unpredictable and when you goof with EFI tuning and boost, bad things happen quickly! Remember back in the early 90's I had Injection Research Services apply EFI to my Yamaha Exciter triple and we ran 50 gallons of Av gas through my engine on their dyno creating a semi-perfect map. It takes about ½ hour and a half gallon of fuel on the dyno to create optimal carburetion from idle to WOT at all RPM. The most excellent attribute of those "antiquated" carburetors is, when airflow increases so does fuel delivery. But with EFI, you must instruct the ECU to deliver X fuel at every RPM and throttle position, and then add another axis for boost pressure!

So when Don Emery talked to me last year about turbocharging Tommy's big quad and fueling it with EFI I cringed thinking about putting 50 gallons of gas through the quad engine on my dyno creating a proper map. And then I thought that since Tommy's turbo engine would make 5x more power than my Yamaha, that might be 250 gallons of dyno tuning fuel—not 50! So I directed him to Gus Bohne, hoping that his system of blowing through 44mm Mikunis would do the job.

So after these co-conspirators—Don and Gus got done conniving, Tommy's wild 1700cc quad was reconfigured for boost, and fitted with a locomotive-sized Garrett ball bearing turbocharger and four Mikuni 44mm round slide carbs, along with a huge air/air intercooler (lots of cooling air is available at 200 mph!) and a boost referenced fuel system worthy of a promod drag car.

The first dyno session on this engine late last winter was skewed because I had the wrong engine/ dyno ratio entered into the SuperFlow dyno program leading me to believe revs were 1.5 times higher than actual! So after discovering my faux pas I offered Tommy and Don a complimentary repeat dyno test but with the proper 1/1 ratio dialed in so we could see real revs above 6000! So this week Don and Curtis Emery would bring the quad monster from Ontario, Canada and Gus Bohne would come from NH to provide boost/ carb tuning/ moral support. And Gus would also bring a turbocharged Polaris 1080 HTG Polaris based triple owned by Art Bass of Utica, NY for dialing in and assessing HP. The third member of the triage would by Steve Bueti from warren, MI with a boosted, carbureted SkiDoo Mach Z twin that Gus had created. And here are the results of this most incredible two day tuning session.

Polaris 1080 HTG triple with Gus Bohne Turbo System

Engine one was great on Gus' jackstand, but fraught with some gremlins with midrange WOT loading with our SF902 dyno that Gus attributed to carb angle and components. We got this one to gurgle and rattle a bit due to some carb/ MSD issues, but Gus knew it wasn't correct so we yanked Sled One from the dyno and went on to number two. This was a bit of a heartbreaker because the big two stroke normally aspirated triples are currently relegated to the sidelines as the result of the huge boosted four-strokes and boosted factory EFI two-stroke Cats. Success with this 1080 triple will likely create a revival for many 100s of big two stroke triples that can once again be competitive in open mod racing with the application of properly tuned boost. Gus will rectify the carbs, and be back with this important machine in early 2012.

SkiDoo Mach Z twin, 990 cc with Gus Bohne Turbo System

Steve Bueti of Warren, MI has worked with Gus for a year, creating and dialing in this turbocharged SkiDoo Mach Z twin on the ice. As we've seen on this website, creating truly big Mach Z horsepower has been difficult, even in big bore versions. Why not boost it? Gus modified Steve's Mach Z by stripping all of the troublesome OEM electronics from it—including EFI and the mechanical exhaust valves, which now are plugged. An MSD ignition creates optimal spark and timing curve along with huge launch boost if needed. Gus also changed the exhaust ports to be more boost friendly, then modified the stock head with lower compression and revised squish band. The heavy duty crankshaft is trued, pinned and welded by Mark Hildebrand of the Sea-Doo Clinic in Michigan. Stock reeds are used here. Once again, 44mm carbs are fitted with fuel delivered with a boost referenced fuel pressure regulator (fuel pressure is proprietary). A custom single pipe/ stock Y pipe creates a wide flat HP curve that should be easy to clutch to. The turbocharger is a large Garrett ball bearing unit, and a water/ air intercooler takes care of excessive charge air temperature. The boost controller is an electronic unit that delivered precise boost pressure. Those of you who observed this test session on the DynoCams saw early misfire that Steve finally diagnosed as a loose MSD ground wire. After electrical continuity was achieved, all was well. Here is a synopsis of the dyno tune, from 20 psi boost to "let's stop right here at 400+ HP". Gus suggested that we could have fun at 35 psi boost with this big turbo, but this is where we opted to quit. Also note that on the final test I was pulling back on the throttle just after we passed 400 HP, hence the drop in fuel flow at high revs. And also note how low the backpressure in the single tuned pipe is—ensuring high airflow that will help purge the combustion chambers of those nasty active radicals that create detonation! It looks like ideal turbine housing sizing by Gus.

Mach Z boosted with 20 psi

EngSpd RPM	STPPwr CHp	STPTrq Clb-ft	BSFCAB lb/hph	FulAB lbs/hr	AirInT degF	BoostP psig	ExhPrs Psig	FulPrA psig
7100	323.7	239.5	0.626	193.5	38.2	20.3	21.2	
7200	329.4	240.3	0.625	196.5	38.2	20.4	21.6	
7300	337.1	242.5	0.613	197.2	38.2	20.4	21.6	
7400	342.4	243.0	0.606	198.1	38.2	20.5	21.6	
7500	345.7	242.1	0.600	198.0	38.2	20.5	21.5	
7600	348.5	240.8	0.597	198.3	38.2	20.5	21.0	
7700	349.8	238.6	0.593	197.8	38.2	20.6	21.1	
7800	349.7	235.4	0.586	195.3	38.2	20.7	21.4	
7900	349.1	232.1	0.589	196.0	38.2	20.7	21.4	
8000	346.3	227.3	0.600	198.1	38.2	20.6	21.5	
8100	341.3	221.3	0.619	201.3	38.2	20.5	21.6	
8200	335.2	214.7	0.639	204.3	38.2	20.6	21.7	
8300	325.7	206.1	0.645	200.2	38.2	20.7	21.6	
8400	308.5	192.9	0.657	193.1	38.2	20.6	21.3	
8500	284.2	175.6	0.675	182.5	38.2	20.5	20.5	

Mach Z boosted with 23 psi

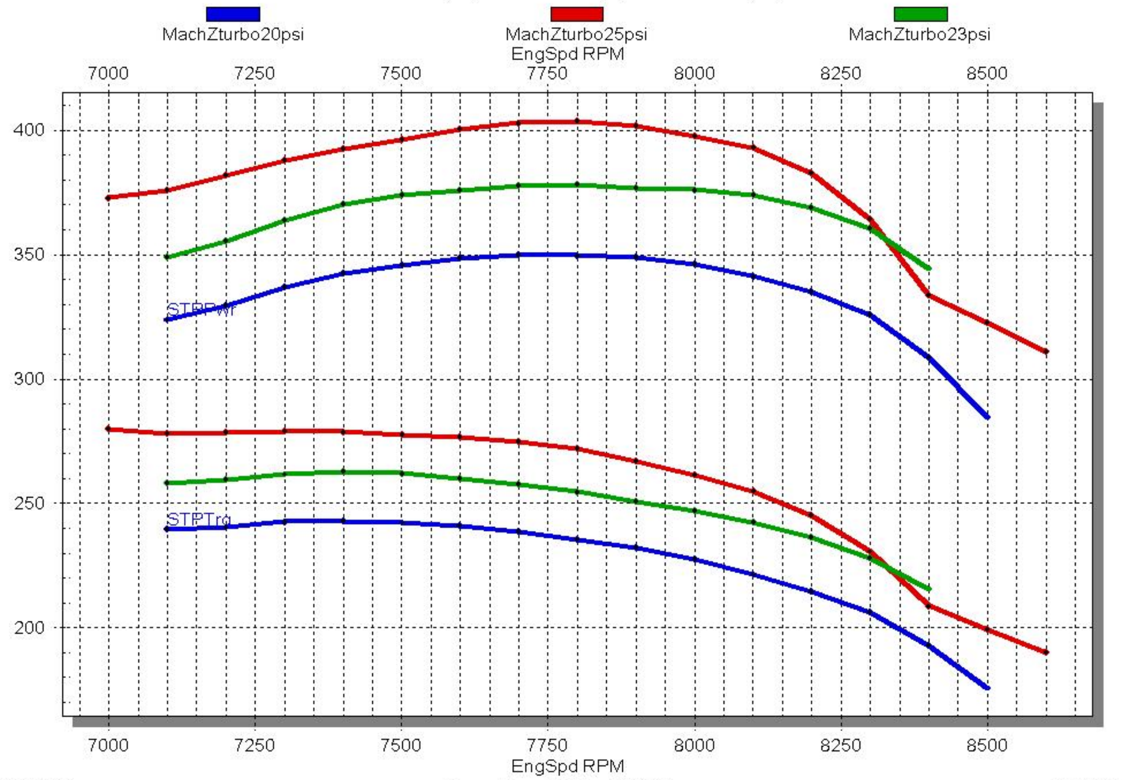
EngSpd RPM	STPPwr CHp	STPTrq Clb-ft	BSFCAB lb/hph	FulAB lbs/hr	AirInT degF	BoostP psig	ExhPrs psig	FulPrA psig
7100	349.0	258.2	0.586	195.0	38.5	22.8	24.0	
7200	355.6	259.4	0.586	198.8	38.5	23.0	24.2	
7300	363.6	261.6	0.587	203.7	38.5	23.1	24.3	
7400	370.4	262.9	0.590	208.5	38.5	23.1	24.5	
7500	374.2	262.0	0.595	212.4	38.5	23.2	24.7	
7600	376.0	259.9	0.596	213.7	38.5	23.4	25.2	
7700	377.7	257.6	0.588	211.9	38.5	23.4	25.0	
7800	378.1	254.6	0.580	209.0	38.5	23.3	24.8	
7900	376.9	250.6	0.594	213.4	38.5	23.2	24.6	
8000	376.1	246.9	0.600	215.0	38.5	23.2	24.5	
8100	374.0	242.5	0.606	216.2	38.5	23.2	24.5	
8200	368.8	236.2	0.605	212.6	38.5	23.2	24.5	
8300	360.5	228.1	0.617	212.0	38.5	23.3	24.5	
8400	344.4	215.3	0.607	199.3	38.5	23.3	24.3	

Mach Z boosted with 25 psi

EngSpd	STPPwr	STPTrq	BSFCAB	FulAB	AirInT	BoostP	ExhPrs	FulPrA
RPM	CHp	Clb-ft	lb/hph	lbs/hr	degF	psig	Psig	psig
7000	372.9	279.8	0.644	229.0	39.0	24.3	26.4	
7100	375.8	278.0	0.659	236.0	39.0	24.5	26.8	
7200	381.8	278.5	0.665	242.0	39.0	24.5	27.0	
7300	387.9	279.1	0.667	246.5	39.0	24.6	27.1	
7400	392.7	278.7	0.670	250.9	39.0	24.7	27.3	
7500	396.3	277.5	0.666	251.6	39.0	24.9	27.4	
7600	400.4	276.7	0.667	254.6	39.0	25.0	27.6	
7700	403.0	274.9	0.656	251.8	39.0	25.2	27.7	
7800	403.8	271.9	0.661	254.5	39.0	25.2	27.7	
7900	401.7	267.0	0.665	254.6	39.0	25.2	27.6	
8000	397.8	261.2	0.670	253.8	39.0	25.1	27.6	
8100	393.1	254.9	0.680	254.5	39.0	25.1	27.5	
8200	382.7	245.1	0.685	249.7	39.0	25.1	27.4	
8300	364.4	230.6	0.700	242.7	39.0	25.2	27.4	
8400	333.8	208.7	0.507	161.1	39.0	25.3	26.0	
8500	322.6	199.3	0.348	106.9	39.0	25.4	24.8	
8600	311.0	190.0	0.263	77.8	39.0	25.3	23.5	

Mach Z w/ Gus Bohne Turbo System

MachZturbo20psi, MachZturbo25psi, MachZturbo23psi,



12/30/11 *SuperFlow WinDyn™ V3.2* *14:53:44*

Gus, Steve, Curtis and Don celebrate big power and a perfect tune! Note the inline air/ water intercooler feeding the big twin.

DNE custom 1700cc four cylinder with Gus Bohne Turbo System

Here is the monster DNE 1700 quad now fitted with boost thanks to Gus Bohne, and with the dyno correctly programmed to show direct drive from crank taper to the SuperFlow dyno absorption unit.

The quad pipes on this engine have been replaced with Gus' recommended twin pipes—one Y pipe connecting cylinders one and two, and another connecting cylinders three and four, and two huge tuned pipes connecting Y pipes to turbine inlet. With this setup, there was an extra 1/8th npt fitting which we could use to measure pipe Center Section temperature and pressure. Note that pipe center section temperature is critical in extending the HP curve beyond 8000 RPM—something that should be monitored to ensure maximum performance on the ice. As the graph shows, the more boost we added, the hotter the CS became, extending revs. With normally aspirated engines building optimal pipe CS temp on the dyno is a matter of holding the engine WOT steady state at low RPM, then beginning the test after the pipe temp is ideal. But with this brutal engine, I loaded the engine at 7700 just long enough to allow boost to rise then began each test. But building optimal initial pipe heat will be easier in the field with the stutter feature that Gus programs the MSD ignition with. This way, ignition is interrupted just below clutch engagement, which causes fuel to burn in large quantities in the pipes, causing pipes to heat quickly, and boost to rise to as high as 12 psi before launching!

DNE 1700 11 psi boost

EngSpd	STPPwr	STPTrq	BSFCAB	FulAB	Pipe CS	BoostP	ExhPrs	FulPrA
RPM	CHp	Clb-ft	lb/hph	lbs/hr	deg F	psig	psig	psig
7700	458.7	312.9	0.645	285.9	890	11.5	12.9	
7800	463.8	312.3	0.644	288.3	912	11.5	13.3	
7900	465.2	309.3	0.641	288.2	930	11.5	13.4	
8000	459.9	301.9	0.654	290.3	946	11.5	13.5	
8100	387.3	251.1	0.743	277.7	951	11.2	12.4	
8200	345.6	221.4	0.832	277.2	943	10.9	11.9	
8300	294.9	186.6	0.976	277.3	930	10.6	11.7	

DNE 1700 15 psi boost

EngSpd	STPPwr	STPTrq	BSFCAB	FulAB	pipe CS	BoostP	ExhPrs	FulPrA
RPM	CHp	Clb-ft	lb/hph	lbs/hr	deg F	psig	psig	Psig
7600	523.9	362.0	0.568	288.9	960	15	17	
7700	529.6	361.2	0.572	294.2	978	15.1	17.2	
7800	539.1	363.0	0.572	299.2	994	15.2	17.6	
7900	548.1	364.4	0.573	305.0	1008	15.2	17.8	

8000	550.9	361.7	0.579	309.7	1020	15.2	17.8	
8100	544.4	353.0	0.587	310.0	1033	15.2	17.8	
8200	453.6	290.5	0.645	283.9	1029	14.8	16.4	
8300	413.3	261.5	0.710	284.4	1015	14.6	15.9	
8400	367.9	230.0	0.815	290.3	995	14.3	15.6	

DNE 1700 18 psi boost

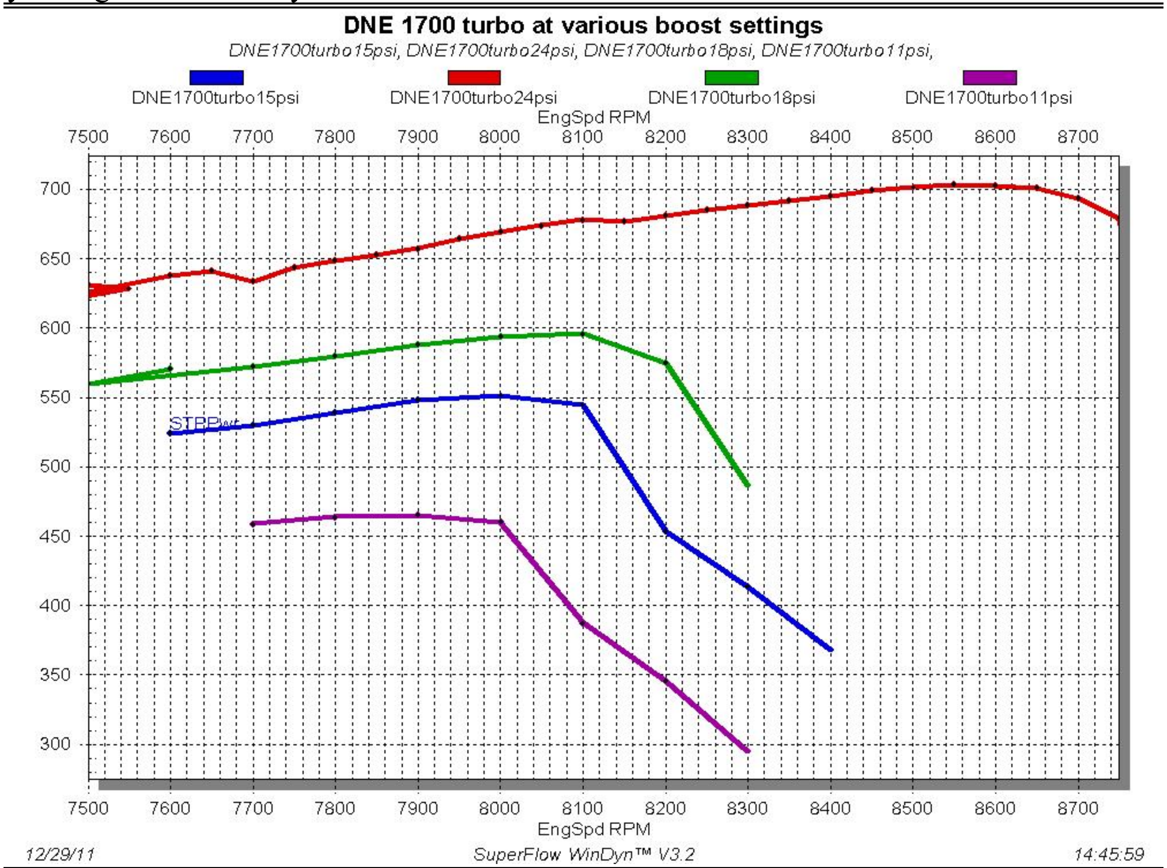
EngSpd	STPPwr	STPTrq	BSFCAB	FulAB	Pipe CS	BoostP	ExhPrs	FulPrA
RPM	CHp	Clb-ft	lb/hph	lbs/hr	deg F	psig	psig	Psig
7600	570.5	394.3	0.577	320.3	944	17.5	20.7	
7500	559.7	391.9	0.594	323.7	963	17.5	20.8	
7700	572.2	390.3	0.592	329.7	984	17.6	20.8	
7800	579.3	390.0	0.589	332.0	989	17.6	20.8	
7900	588.0	390.9	0.587	335.8	1003	17.7	21.2	
8000	593.6	389.7	0.583	336.9	1014	17.8	21.5	
8100	595.7	386.2	0.580	336.1	1023	17.9	21.7	
8200	574.8	368.2	0.599	335.0	1042	17.9	21.4	
8300	486.8	308.1	0.678	320.7	1035	17.5	19.6	

DNE 1700 24 psi boost

EngSpd	STPPwr	STPTrq	BSFCAB	FulAB	Pipe CS	BoostP	ExhPrs	FulPrA
RPM	CHp	Clb-ft	lb/hph	lbs/hr	deg F	psig	psig	psig
7300	615.5	442.8	0.572	342.0	1173	22.8	27.0	
7350	620.6	443.5	0.566	340.8	1175	22.8	27.0	
7500	631.1	442.0	0.562	344.2	1180	22.8	27.1	
7550	628.1	436.9	0.576	351.4	1186	22.9	27.2	
7450	617.8	435.6	0.589	353.4	1190	22.9	27.3	
7400	614.4	436.0	0.592	352.9	1192	22.9	27.4	
7600	637.3	440.4	0.569	351.9	1204	23.1	27.6	
7650	640.7	439.9	0.567	352.6	1206	23.1	27.7	
7700	633.6	432.2	0.585	359.9	1223	23.3	28.1	
7750	643.2	435.9	0.580	362.2	1238	23.3	28.4	
7800	648.2	436.5	0.577	363.0	1240	23.3	28.5	
7850	652.9	436.8	0.574	363.6	1242	23.3	28.5	
7900	657.1	436.9	0.572	364.6	1246	23.3	28.5	
7950	664.0	438.7	0.573	369.3	1275	23.4	28.8	
8000	669.2	439.3	0.569	369.6	1279	23.4	28.9	
8050	673.7	439.6	0.566	370.0	1281	23.5	28.9	
8100	677.8	439.5	0.564	370.7	1285	23.5	28.9	
8150	676.9	436.2	0.565	371.0	1304	23.7	29.2	
8200	680.6	435.9	0.563	371.6	1311	23.8	29.3	
8250	684.6	435.9	0.562	373.0	1316	23.8	29.3	
8300	688.2	435.5	0.561	374.8	1323	23.9	29.3	
8350	691.2	434.8	0.562	376.8	1335	24.0	29.2	
8400	695.1	434.6	0.562	378.7	1342	24.0	29.2	
8450	698.8	434.3	0.562	380.9	1349	24.0	29.3	
8500	701.2	433.3	0.565	384.1	1358	24.1	29.6	
8550	703.4	432.1	0.568	387.4	1369	24.2	29.7	
8600	702.1	428.8	0.565	385.0	1392	24.3	30.0	
8650	700.9	425.6	0.565	383.7	1407	24.4	30.2	

8700	692.9	418.3	0.569	382.4	1431	24.5	30.2
8750	679.4	407.8	0.581	382.5	1460	24.6	30.3
8800	547.1	326.5	0.543	287.7	1590	24.8	29.2

Note that with the last dyno test we switched to recording data every 50 RPM to display the max possible HP. And also note that with this final high power blast of exhaust, the pipes' center section temp climbed to nearly 1500 degrees F even with safe fuel flow and zero knock, greatly extending the HP curve. But some of that beyond 8600 RPM data may have been skewed by the dyno operator pulling back on the throttle instantly as people in the control room shouted as 700 HP appeared on the dyno monitor! To the guy at the controls, hollering control room observers is cause for aborting the test—are dyno shaft parts flying, or are gasoline fueled flames licking the dyno room ceiling? So when you see fuel flow and HP drop fairly sharply at 8800, that is the result of "Chicken Jim" yanking back on the dyno throttle control!



Gus and our mad Canadian pals Matt, Don and Curtis celebrate once more!